ELECTROTEK CONCEPTS

Hawaii Wind Working Group
Inaugural Meeting

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Maintaining and Operating "The Grid"

- Traditional Utility Functional Areas
  - Design
  - Operations
  - Planning
- Effect of Industry Transformation
  - Technical issues remain unchanged
  - Relocation of traditional responsibilities and authority

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What do windplants "look like"?

- Must know to determine how windplants affect the grid
- "Describing" windplants
  - Real power output vs. time
  - Reactive power demand or output vs. time
  - Changes in real power vs. time
  - Changes in reactive power vs. time
- So what do they "look like"?

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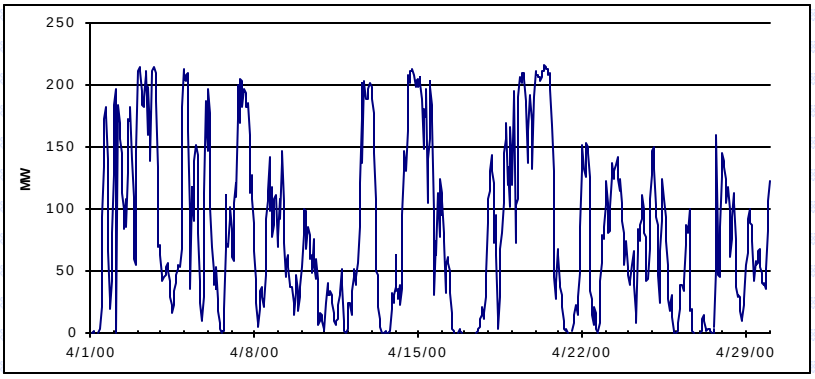
Not so good, maybe…

*210 MW Windplant in Midwestern U.S.**



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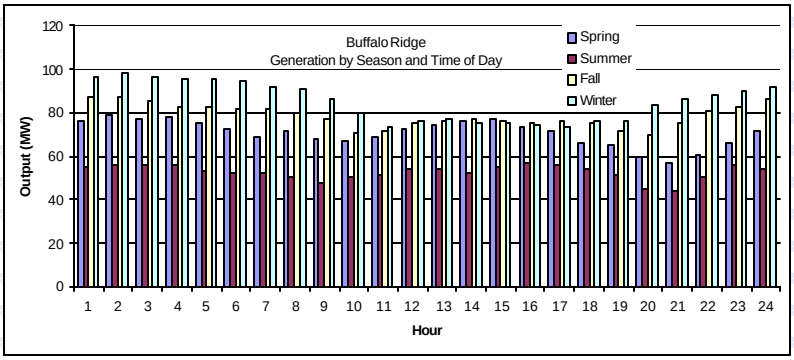
**courtesy National Renewable Energy Laboratory*

Energy looks a little better…



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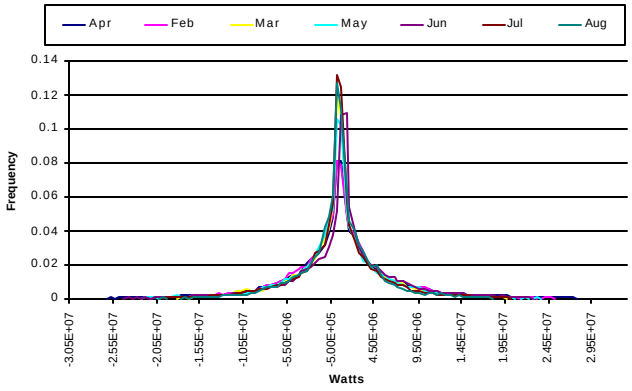
But maybe Power isn't so bad either…

Output Variations of 250 MW Windplant
Load-Following (minute-by-minute) time frame



10 MW

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Technical Issues

- Voltage and service quality impacts
- Impacts on real-time operations and scheduling
- Ancillary service issues and questions
- Transmission issues - allocating capacity
- Reliability and security

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Voltage and Quality Issues

- Voltage regulation
  - Maintaining voltage at all points and at all times in the network within acceptable window
  - Windplant reactive power and power factor
- Service Quality
  - Flicker – does changing P lead to changing V?
  - Do turbine starts cause voltage to “dip”?
  - Do the turbines create harmonic distortion?

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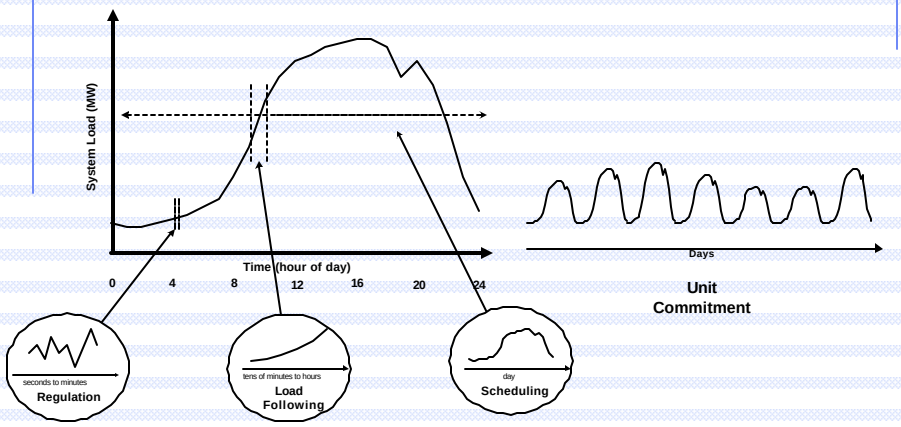
Generation Scheduling and Operations



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Operator's Dilemma

- Frequency control: *Do windplants make it more difficult to regulate "frequency"?*
- Regulation: *Can windplants affect or increase the area control error (ACE)?*
- Load following: *What happens if windplant output decreases in the morning when load is increasing?*
- Scheduling: *How can committed units be scheduled for the day if windplant output cannot be predicted? What happens if the wind forecast is inaccurate?*
- Committing generating units: *Looking out over the next few to several days, how should or could windplant production be factored into planning what generation units need to be available? Is the effective amount of reserves influenced?*

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Economic Questions

- Cost is the primary metric
- Committing generation that is not needed increases cost
- Scheduling generation that is not needed can increase cost
- Allocating extra load-following capability increases cost
- Violation of system performance criteria can increase cost
- How can these costs be minimized? And, who pays for what is left?
  - Forecasting?
  - Tariffs?
  - Technology?

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Ancillary Services

- Definitions
  - Voltage regulation and VAR dispatch
  - Regulation
  - Load following
  - Frequency-responding spinning reserve
  - Supplemental Reserve
- By-products of conventional power system operations
- To be bought and sold on the market in the new industry paradigm

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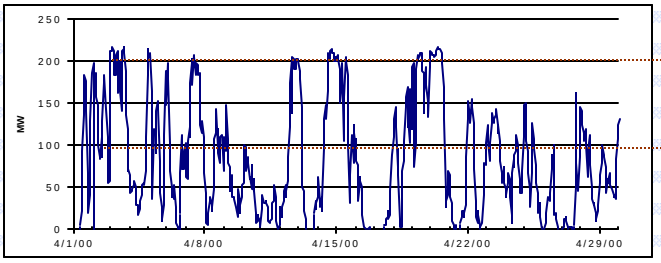
Transmission Capacity Issues

- How do I plan/design/reserve/procure transmission (delivery) capacity for this:



- Present competitive market mechanisms not favorable for wind
- Same issue exists in conventional utility perspective

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Reliability and Security

- Definitions
  - Reliability – probability that available generation will be sufficient to meet demand (very high number, e.g. 99.9%)
  - Security – operate the system in a manner such that it keeps going if something "breaks"
- Vertical utilities and Markets must consider both
- Relevance to wind
  - Capacity (vs. energy) questions (longer-term)
  - Operating restrictions and forced curtailment

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Status

- Still many questions
- Starting to find a few answers
- Transitory nature of power industry is current complication
- Experience and Technology will provide additional answers